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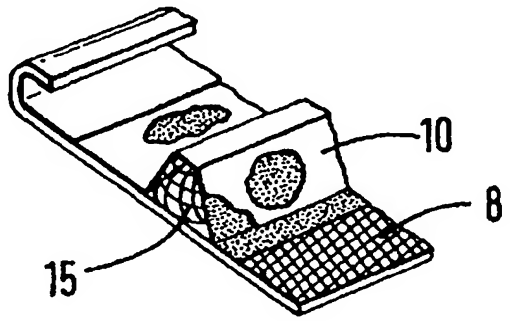
(54) Screen assembly, vibratory separator and method of screening

(57) A screen assembly for a vibratory separator, the screen assembly comprising a ridge-valley series of screening material (14, 16; 31, 32, 33, 34; 43) having a plurality of alternating ridges (18; 41) and valleys (20; 42) and two spaced apart ends having ridge openings below the ridges, said openings covered with screen or mesh material characterised in that said openings are covered with screen or mesh material (14; 44) in a generally bulbous shape.

A vibratory shaker including the screen assembly of the invention.

A method for screening using the vibratory separator of the invention said method comprising the step of vibrating said ridge-valley series of screening material, pouring a particle laden fluid on to one of said ridge-valley series of screening material thereon, allowing fluid and predetermined size particles therethrough, and vibrating particles larger than said predetermined size to a far end of one other of said ridge-valley series of screening material.

FIG. 1B



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Description

[0001] The present invention relates to a screen assembly, a vibratory separator and a method of screening.

[0002] When drilling a wellbore in the earth's surface, drilling fluid is used to maintain the tip of a drill cool and to carry solids to the surface of the wellbore. Once at the surface the solids are removed from the drilling fluid which can then be re-used.

[0003] Types of apparatus that can remove solids from drilling fluid include a vibratory separator known as shale shaker. A typical shale shaker is disclosed in PCT Publication No. WO 96/33792. Typically, it is known to provide such equipment with one or more screens of wire mesh for filtering the drilling fluid. Typically, the wire mesh is very fine and does not have a high durability. It is advantageous to have a screen which has high durability.

[0004] Shale shakers are limited in size, especially those used on offshore platforms where space is at a premium. Accordingly, it is advantageous to filter a large quantity of particle laden mud using standard size shale shakers.

[0005] It is also advantageous for screens to be easily replaceable and repairable.

[0006] It is also advantageous to increase the residence period of the particle laden fluid on the screen.

[0007] A first aspect of the present invention provides a screen assembly for a vibratory separator, the screen assembly comprising a ridge-valley series of screening material having a plurality of alternating ridges and valleys and two spaced apart ends having ridge openings below the ridges, said openings covered with screen or mesh material characterised in that said openings are covered with screen or mesh material in a generally bulbous shape.

[0008] Preferably, the screen assembly further comprises a hook strip connection apparatus on spaced-apart sides of said at least two ridge-valley series of screening material.

[0009] Advantageously, the ridges are of at least two different sizes.

[0010] Preferably, the ridges are of at least two different widths.

[0011] Advantageously, the ridges are of a least two different heights.

[0012] Preferably, the screen assembly comprises two side portions and a central portion, wherein said ridges decrease in size from said side portions towards said central portion.

[0013] Advantageously, the ridges decrease in height.

[0014] Preferably, the screening material further comprises at least a second layer of screening material.

[0015] Advantageously, the screen assembly comprises at least one further ridge-valley series of screening material having a plurality of alternating ridges and valleys of screening material, wherein at least one of the ridge-valley series of screening material is offset from at least one other ridge-valley series of screening material.

[0016] Preferably, the screen assembly comprises a second screen, wherein the ridges of said second screen are in line with the ridges of said first screen.

[0017] Advantageously, the screen assembly further comprises a flat screen of screening material, said ridge-valley series on said flat screen.

[0018] Preferably, the flat screen is made of coarse mesh and said ridge-valley series are made of fine mesh.

[0019] The first aspect of the present invention also provides a vibratory separator comprising a screen assembly for a vibratory separator, the screen assembly comprising a ridge-valley series of screening material having a plurality of alternating ridges and valleys and two spaced apart ends having ridge openings below the ridges, said openings covered with screen or mesh material characterised in that said ends are covered with screen or mesh material in a generally bulbous shape.

[0020] The first aspect of the present invention further provides a method for screening using the vibratory separator of the invention said method comprising the step of vibrating said ridge-valley series of screening material, pouring a particle laden fluid on to one of said ridge-valley series of screening material thereon, allowing fluid and predetermined size particles therethrough, and vibrating particles larger than said predetermined size to a far end of one other of said ridge-valley series of screening material.

[0021] According to a second aspect of the present invention, there is provided a screen comprising screening material formed with ridges characterised in that said ridges are of at least two different heights.

[0022] Preferably, the ridges are of at least two different widths.

[0023] Advantageously, the screen comprises two side portions and a central portion, wherein said ridges decrease in height from said side portions towards said central portion.

[0024] Preferably, the screening material further comprises at least a second layer of screening material.

[0025] Advantageously, the screen further comprises a flat screen arranged below said screening material.

[0026] Preferably, the screen further comprises hook strip connection apparatus on sides of said screening material.

[0027] Advantageously, the screen further comprises screening material over openings formed by said ridges to inhibit flow of large particles therethrough.

[0028] Preferably, the screen further comprises an end stop at ends of said ridges to inhibit flow of fluid therethrough.

[0029] There is also provided vibratory shaker comprising a screen of the second aspect of the invention. Preferably, the vibratory shaker comprises a second

screen, wherein said ridges are in line with ridges of said first screen. If desired, the vibratory shaker may comprise a further screen with ridges which are optionally offset from said ridges of said first screen.

[0030] According to a third aspect of the present invention there is provided a screen for a shale shaker, said screen comprising screening material having a plurality of ridges and at least two sides a forward end and a trailing end, characterised in that said ridges run from said forward end to said trailing end at an acute angle to one of said sides.

[0031] Preferably, the angle is in the range 5° to 25°.

[0032] Advantageously, the angle is in the range 10° to 20°.

[0033] Preferably, the screen comprises a further plurality of ridges run from a forward end to a trailing end at an acute angle to said other of said sides.

[0034] Advantageously, the screen has a left side area and a right side area, wherein said plurality of ridges are arranged on said left side area, said further plurality of ridges arranged on said right side area.

[0035] Preferably, the screening material further comprises at least a second layer of screening material.

[0036] Advantageously, the screen further comprises a flat screen arranged below said screening material.

[0037] Preferably, the screen further comprises hook strip connection apparatus (55; 121, 122) on said sides.

[0038] Advantageously, the screen further comprises screening material over openings formed by said ridges to inhibit flow of large particles therethrough.

[0039] Preferably, the screen further comprises an end stop at ends of said ridges to inhibit flow of fluid therethrough.

[0040] There is also provided a screen assembly for a vibratory separator, the screen assembly comprising at least two ridge-valley series of screening material including at least a first series adjacent a second series, said first series comprising a first side series and a second side series each of a plurality of ridges and valleys, said first side series at an angle to said second side series as viewed from above, and said second series comprising a third side series and a fourth side series each of a plurality of ridges and valleys, said third side series at an angle to said fourth side series as viewed from above.

[0041] The third aspect of the present invention also provides a vibratory separator comprising a screen as of the third aspect of the invention.

[0042] A fourth aspect of the invention provides a screen comprising screening material having a at least one elongate ridge and valley, characterised in that said ridge differs in shape therealong.

[0043] Preferably, the shape has a consistent screening area when measured at discrete locations along said ridge.

[0044] Advantageously, the elongate ridge comprises a first side rising from said valley, a substantially horizontal top portion, a second side falling into a second valley and a substantially horizontal valley floor, wherein the height and width of said substantially horizontal top portion differ linearly therealong.

[0045] Preferably, the screening material further comprises at least a second layer of screening material.

[0046] Advantageously, the screen further comprises a flat screen arranged below said screening material.

[0047] Preferably, the screen further comprises hook strip connection apparatus on sides of said screening material.

[0048] There is also provided a screen assembly for a vibratory separator, the screen assembly comprising at least one ridge-valley series of screening material, said ridge-valley series including a plurality of ridges each ridge between valleys of a plurality of valleys, and each ridge having a first end and a second end, said first end having a top wider than a top of the second end.

[0049] Preferably, the second end is higher than said first end.

[0050] Advantageously, the screen assembly further comprises hook strip connection apparatus on spaced-apart sides of said at least one ridge-valley series.

[0051] Preferably, the ends of the ridges of the ridge-valley series of screening material are covered with at least one screen or mesh.

[0052] The fourth aspect of the present invention also provides a vibratory shaker comprising a screen of the fourth aspect of the invention.

[0053] For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1A is a perspective view of a screen apparatus according to a first aspect of the present invention;

Figure 1B is an enlarged view of part of the screen apparatus of Figure 1A;

Figure 1C is a end view taken from line 1C-1C of Figure 1A;

Figure 1D is a end view of a second embodiment of a second screen, similar to the screen of Figure 1A;

Figure 1E is a perspective view of a third screen;

Figure 2A is a perspective view of a screen apparatus according to a second aspect of the present invention; Figure 2B is an enlarged view of part of the screen apparatus of Figure 2A; Figure 2C is a view along line 2C-2C of Figure 2A;

Figures 2D - 2H show a selection of end shapes for ridge end covering according to the present invention;

Figure 3A is a top view of a screen apparatus according to a third aspect of the present invention;

Figure 3B is an end view of the screen apparatus of Figure 3A;

Figure 4 is a top view of a screen according to fourth aspect of the present invention;

Figure 5 is a perspective view of a screen according to the first, second and a fifth aspect of the present

invention;

Figure 6A is a top view of a screen according to the first and third aspect of the present invention; Figure 6B is an end view of the screen of Figure 6A;

Figure 7A is a perspective view of a screen part according to a sixth aspect of the present invention;

Figure 7B is a perspective view of a screen with parts as in Figure 7A;

[0054] Figure 1A - 1C show a screen assembly generally identified by reference numeral 1 for use in, for example, a vibratory shaker such as a shale shaker. The screen assembly 1 has hook strips 2 and 4 on either side thereof. Screening material 6 is connected along the length of each hook strip by known methods, for example folding, welding, crimping together, epoxying, press/fiction fit, and/or interlocking of parts. In one aspect no underlying plate, straps, or strips and no frame are used with the screen assembly 1.

[0055] The screening material 6 may be any known screening material, screen and/or mesh or combination thereof and/or any screening material disclosed herein. In the screen 1 as shown, the screening material 6 includes a lower mesh (for example 1 to 80 mesh) 8 which may be a relatively coarse mesh and an upper mesh 10 (for example 8 to 400 mesh) and which may be a relatively fine mesh. Two fine mesh screens and one coarse mesh screen may also be used. The fine mesh may be bonded to the coarse mesh, sewed to the coarse mesh, glued to it, welded to it, and/or sintered to it.

[0056] An optional perforated plate or a series of straps or strips such as those disclosed in WO 94/23849, may be used below the coarse mesh. One, two, three or more layers of wire mesh may be used instead of or with such a plate, straps, or strips. In one particular aspect a flat coarse mesh (for example mesh 1 to mesh 12) is used instead of or in addition to a plate, straps, or strips.

[0057] Mesh (fine, coarse, or both) is folded over open exposed ends of ridges 14 and 18. This mesh can be substantially flat over the open ridge end or, as shown, it can protrude as part of a bulb or closed curve shape 15. Such shape can provide more screen area for separation and can deflect and re-route solids and fluid to a subsequent set of valleys. Alternatively any or all openings may be plugged with a solid, porous, or perforated plug glued or welded in place. Alternatively, instead of folding screening material and/or mesh over the ends of ridges, a separate piece of screen, screens, mesh, and/or meshes can be placed at an open ridge end and the edges of the piece attached to, connected to, interlocked with, interwoven with, and/or adhered to the edges of the ridge end opening. Also, it is within the scope of this invention for any ridge end to be closed off to fluid flow, to be covered with screen(s) and/or mesh, and/or to be plugged. It is within the scope of this invention for all ridge ends on one side of a series of ridges (for example on side 18a or 14a) to be closed off to flow while the other side's ridge ends (for example on side 18b or 14b) are covered with material which permits flow [for example perforated plug, screen(s), mesh(es)]. These possibilities for end closure and end openings may be used with any screen assembly disclosed herein. It is also within the scope of this invention for all ridge ends of all ridge sets to be open.

[0058] A series of valleys or troughs 16 is interspersed between the series of ridges 14. A second series of ridges 18 and valleys 20 is offset from the ridges 14/valleys 16, as shown in Figures 1A to 1D. Alternatively, as shown in Figure 1D the shape of one set of ridges RD can overlap (when viewed on end) the ridges RG of the other set of ridges. The ridges RD are also the same size as the ridges RG, as are the valleys. It is within the scope of this invention to employ any desired amount of such overlap. As shown, for example in Figures 1C and 1D, the ridges are of substantially the same height and ridge ends are of substantially the same cross-sectional area. It is also within the scope of this invention for the ridges of one set of ridges to be of a different width than those of the other set; for the one set to be wider or narrower than the second set; for ridges or ridge ends on one set to have a different cross-sectional area than those of another set; and/or to employ three, four, five, six or more series of offset ridges on a single screen. Optional side paths 22 and 24 may be eliminated by having a ridge edge or ridge adjacent a hook strip 2, 4 side or positioned against a frame side (when an optional frame is used) or side member if hook strips are not used.

[0059] Figure 1E presents a screen apparatus 30 with four sets of offset ridges 31, 32, 33, 34 and hook strip sides 35, 36.

[0060] Figures 2A - 2C show a screen apparatus 40 for use in, for example a vibratory shaker such as a shale shaker. The screen apparatus 40 has a series of ridges 41 and valleys 42 of screening material 43 (like any of the screening material 16, Figure 1A). Ends of ridges are, optionally, covered with screen and/or mesh (or, alternatively, plugged as described above with either solid or perforated plugs) in a closed curved shape or bulbous shape 44 or they may be flat. The screening material 43 extends between side hook strips 45, 46 on a flat screen 47. As shown in Figure 2C, ridges of the set of ridges 41 may have different heights; for example alternating high and low, high in the middle and lower on the ends, or as shown in Figure 2C higher towards the sides and lower in the middle. Any such series of ridges with height differences, with width differences, and, therefore, with differing cross-sectional area and different amount of surface area may be used for any ridge series or part thereof on any screen disclosed herein. As shown in Figure 2C, the height (and also the cross-sectional area as viewed on end as in Figure 2C) of the ridges may gradually decrease from the sides of the screen assembly to the middle. Alternatively, the height (and cross-sectional area) may increase from the screen sides to the screen

middle.

[0061] Figures 2D to 2H show possible shapes for ridge end coverings for the ends 44 (and for any ridge end disclosed herein). The coverings are designated CV-2D, CV-2E, CV-2F, CV-2G and CV-2H for Figures 2D to 2H, respectively.

[0062] Figure 3A shows a screen apparatus 50 for use in, for example a vibratory shaker or shale shaker. The screen apparatus has three sub-screens 51, 52, 53 in an integral unit. Alternatively, three sub-screens may be connected together, for example with an interlock fit or suitable fasteners. It is within the scope of this invention to employ two, four or more appropriately sized sub-screens in an integral unit or interconnected. Each sub-screen has a series of alternating ridges and valleys 51R, 52R, 53R and 51V, 52V, 53V, respectively. Each ridge-valleys is at an angle to hook strip sides SS of each screen, and the angle of the ridge-valley series of sub-screen 52 is different from that of the sub-screens 51 and 53. As shown in Figure 3B, ridges 53R of the sub-screen 53 are lined up with ridges 52R of the sub-screen 52, but it is within the scope of this invention for ridges of any set to be offset with respect to ridges of another set. For any screen in Figures 1A - 3A the hook strip sides may be eliminated and any known suitable edge or side structure may be employed. Any one of the sub-screens 51, 52, 53 may be eliminated and any two adjacent ridge-valley series in any screen herein may be offset as are the sub-screens in Figure 3A.

[0063] Figure 4 shows a screen 70 with mesh 72 supported on spaced-apart straps 76. The mesh 72 may be any suitable known type. In the screen 70, the mesh 72 is, in one aspect, a wire mesh that is bonded to the straps 76.

The straps 76 are secured to hookstrips 74, 75.

[0064] As shown, the screen 70 has three spaced-apart ramps 78, 80, 82. A dewatering area or pool 84 is defined between the two ramps 78, 80 and a dewatering area or pool 85 is defined between the two ramps 80, 82. The ramps or raised portions 78, 80, 82 are offset between the sides of the screen such that, in use, flow of particle laden mud from one end 87 of the screen 70 to the other end 89, will have to pass over at least one ramp 78, 80, 82, or the screen may be provided, as shown with a single flow path 90 located between one end of the ramp 82 and the side with the hookstrap 76. Such a location of the ramp 82 with respect to the strap 76 facilitates dewatering of solids in this area while inhibiting screen wear. Liquid rising to the top can exit through the screen ramp. Similarly a strap 76 traverses the area 90. The screen 70 also has ramped portions 91 to 99 which, in use, are substantially in line with the flow of particle laden fluid. The ramped portions 91 to 99 may alternatively be normal (90° angle) to the ramps 78, 80, 82.

[0065] The ramps 78, 80, 82 are between about three to about five inches wide and about raised about five inches from the pool areas 84, 85. Each ramp 78, 80, 82 has a ramped surface 78a, 80a, 82a, respectively at an angle, preferably, between about twenty to about forty degrees from the horizontal, more preferably between about twenty-five to about thirty degrees, and in one particular aspect about twenty seven- degrees. Each ramp also has a rear face at between about eighty to about one hundred twenty-five degrees to the horizontal, more preferably between ninety and one hundred twenty degrees, and in one particular aspect about one hundred fifteen degrees.

[0066] Figure 5 shows a screen assembly 100 according to the present invention with side hook strips 102 and 104 and a two ridge-valley series 103, 105. Ridges 106 of the series 103 are higher than ridges 107 of the series 105. Any suitable spacing between ridges may be employed. The series 103, 105 may be made of any mesh or screen or meshes or screen combination disclosed herein. Any suitable plate, frame, straps or strips may be used with the screen assembly 100; but in one aspect no such item is used. In use, particle laden mud flows from the lower height series 105 to the higher height series 103; but it is within the scope of this invention to flow from a higher height series to a lower height series. As shown screening material 109, 110 [any screen(s) and/or mesh(es) described herein] is connected to (in any way disclosed herein) an optional flat coarse mesh 111.

[0067] Figure 6A shows a screen assembly 120 comprising hook strips 121, 122 and two series of ridge-valley screen material 123, 124 which have ridges 126, 126a and valleys 127, 127a arranged on one side angled to direct flow generally toward the centre of the screen assembly, and ridges 128, 128a and valleys 129, 129a arranged on the other side angled to direct flow generally toward the centre (and may converge with ridges 126, 126a and valleys 127, 127a at the centre). The screening material of the series 123, 124 is, optionally, connected to a flat coarse mesh 125. Although optional, any plate, frame, strips, or straps disclosed herein may be used with the assembly 120.

[0068] Figure 7B shows a screen assembly 150 comprising side hook strips 151, 152 and a series of ridge-valleys 153. Each ridge 154 of the series 153 is higher at one end than the other, as illustrated in Figure 7A. Any desired height difference may be employed and in use, particle laden fluid may flow either way between the sides, from the higher ridge end 155 to the lower end 156, or vice versa. Also, a ridge end top 155 is narrower than a ridge end top 156. Alternatively, the end 155 may be wider than the end 156. Any ridge disclosed herein or any series of ridges disclosed herein may have a height differential from end-to-end (as shown herein) and/or any ridge disclosed herein may have one ridge end of a particular ridge wider than the other end of the ridge and/or with different cross-sectional area. The series 153 is made of any screening material [screen(s) and/or mesh(es)] disclosed herein. The series 153 is, optionally, connected to a flat coarse screen (any dis-

closed herein) 157. Alternatively or in addition to the screen 1686 any plate, frame, strap or strips disclosed herein may be used. In one particular aspect the linear measurement E1=E2 and A1+B1+C1+D1 = A2+B2+C2+D2, although any suitable desired lengths may be employed, and one end (the end 155) is higher than the end 156. Ridge ends of the assembly 155, 156 (as may be any ridge end disclosed herein) may be covered or plugged in any way as described above.

Claims

1. A screen assembly for a vibratory separator. the screen assembly comprising a ridge-valley series of screening material (14, 16; 31, 32, 33. 34; 43) having a plurality of alternating ridges (18; 41) and valleys (20; 42) and two spaced apart ends having ridge openings below the ridges, said openings covered with screen or mesh material **characterised in that** said openings are covered with screen or mesh material (14; 44) in a generally bulbous shape.

2. A screen assembly as claimed in Claim 1, further comprising a hook strip (1,4) connection apparatus on spaced-apart sides of said at least two ridge-valley series of screening material (14, 16).

3. A screen assembly as claimed in Claim 1 or 2, **characterised in that** said ridges are of at least two different sizes.

4. A screen assembly as claimed in Claim 3, wherein said ridges (41) are of at least two different widths.

5. A screen assembly as claimed in Claim 3 or 4, wherein said ridges (41) are of a least two different heights.

6. A screen assembly as claimed in Claim 3, 4 or 5, said screen comprising two side portions and a central portion, wherein said ridges (41) decrease in size from said side portions towards said central portion.

7. A screen assembly as claimed in Claim 6, wherein said ridges (41) decrease in height.

8. A screen assembly as claimed in any of Claims 3 to 7, wherein said screening material (43) further comprises at least a second layer of screening material.

9. A screen assembly as claimed in any of preceding claim, comprising at least one further ridge-valley series of screening material (16; 31, 32, 33, 34) having a plurality of alternating ridges (18) and valleys (20) of screening material, wherein at least one of the ridge-valley series of screening material (14; 31) is offset from at least one other ridge-valley series of screening material (16; 32).

10. A screen assembly as claimed in any preceding Claim, comprising a second screen, wherein the ridges of said second screen are in line with the ridges of said first screen.

11. A screen assembly as claimed in any of preceding Claim, further comprising a flat screen of screening material, said ridge-valley series on said flat screen.

12. A screen assembly as claimed in Claim 11, wherein said flat screen is made of coarse mesh and said ridge-valley series are made of fine mesh.

13. A vibratory separator comprising a screen assembly for a vibratory separator, the screen assembly comprising a ridge-valley series of screening material (14, 16; 31, 32, 33, 34; 43) having a plurality of alternating ridges (18; 41) and valleys (20; 42) and two spaced apart ends having ridge openings below the ridges, said openings covered with screen or mesh material **characterised in that** said ends are covered with screen or mesh material (14; 44) in a generally bulbous shape.

14. A method for screening using the vibratory separator as claimed in any preceding Claim, said method comprising the step of vibrating said ridge-valley series of screening material, pouring a particle laden fluid on to one of said ridge-valley series of screening material thereon, allowing fluid and predetermined size particles therethrough, and vibrating particles larger than said predetermined size to a far end of one other of said ridge-valley series of screening material.

FIG. 1A

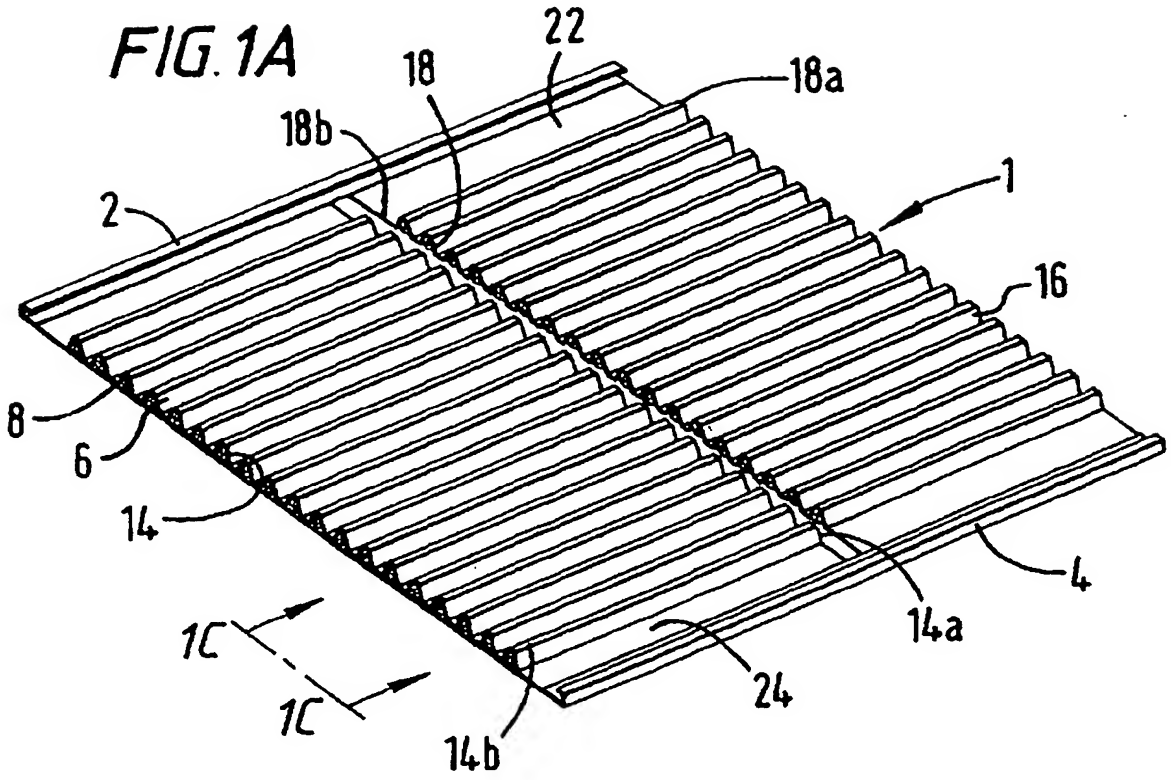


FIG. 1C

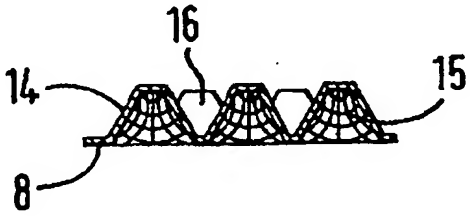


FIG. 1B

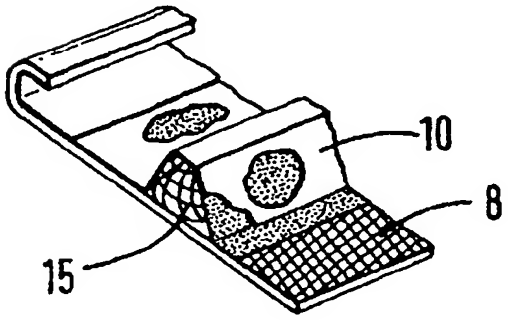
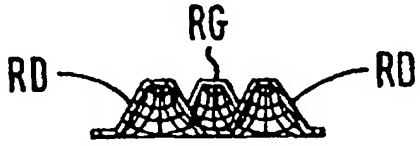


FIG. 1D



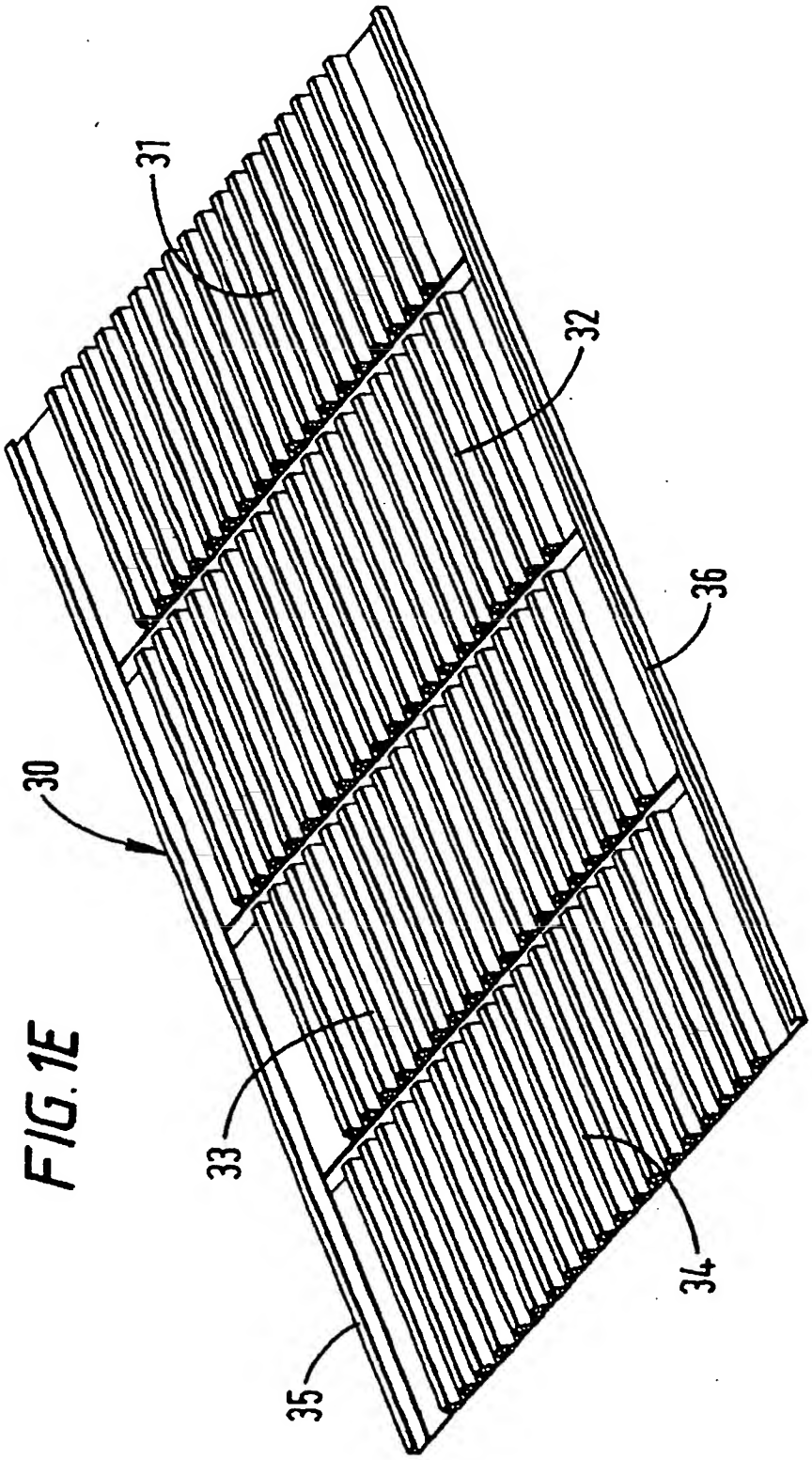


FIG. 1E

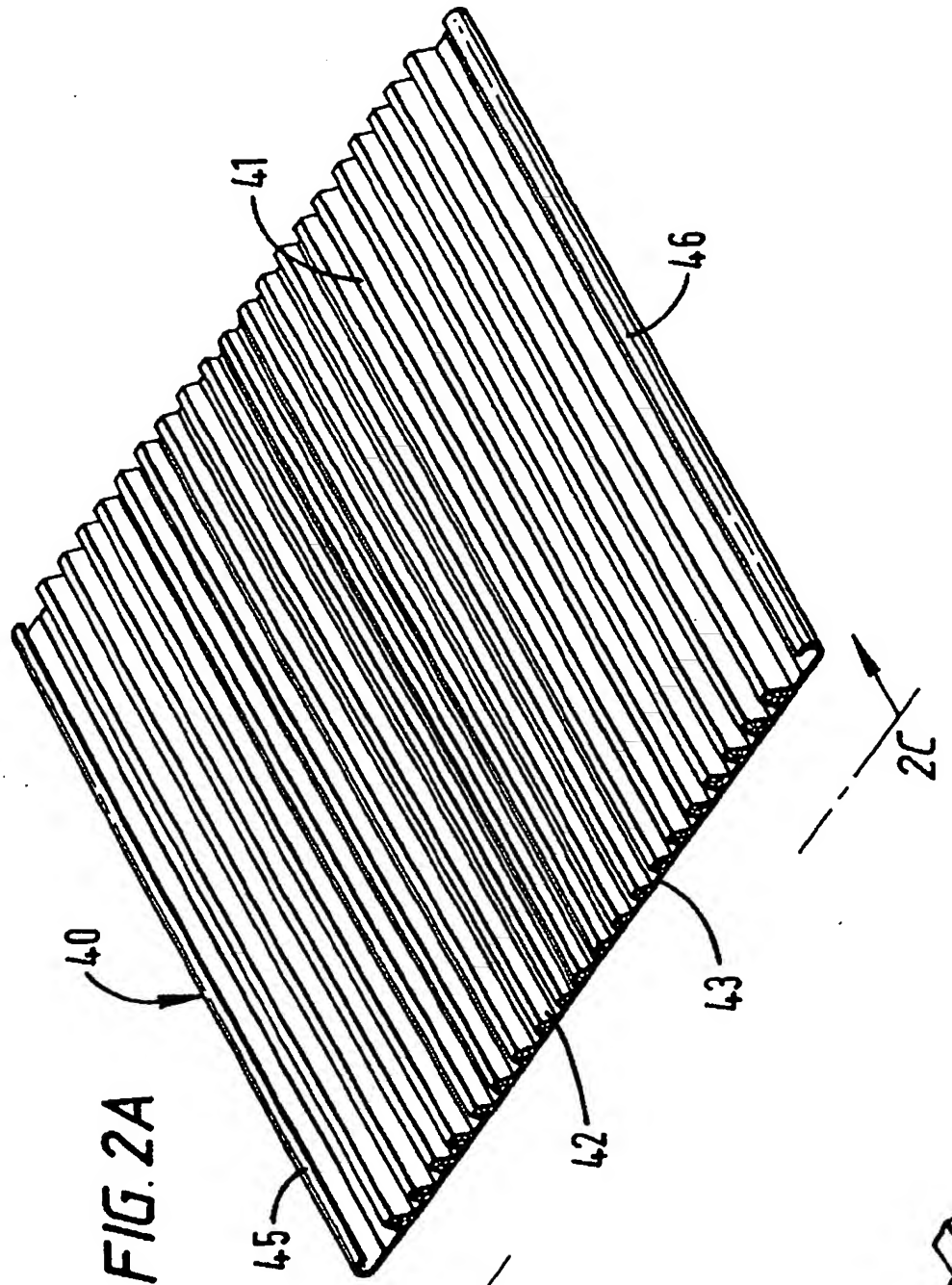


FIG. 2A

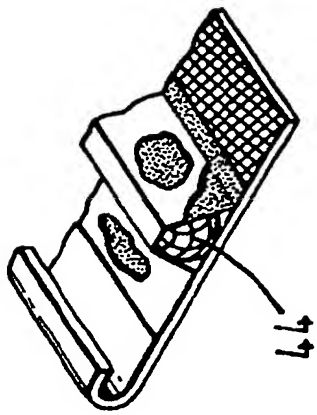


FIG. 2B

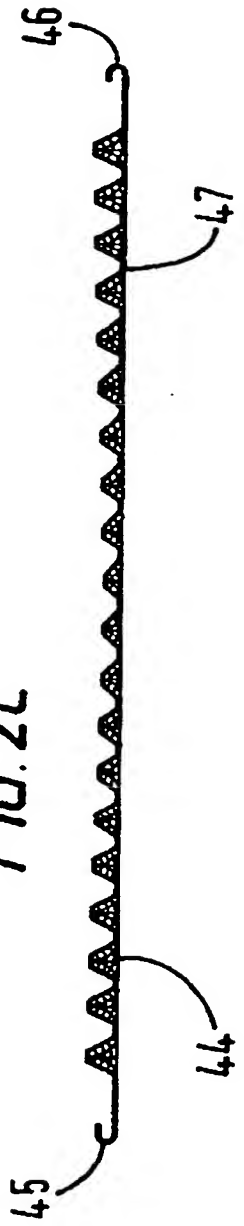


FIG. 2C

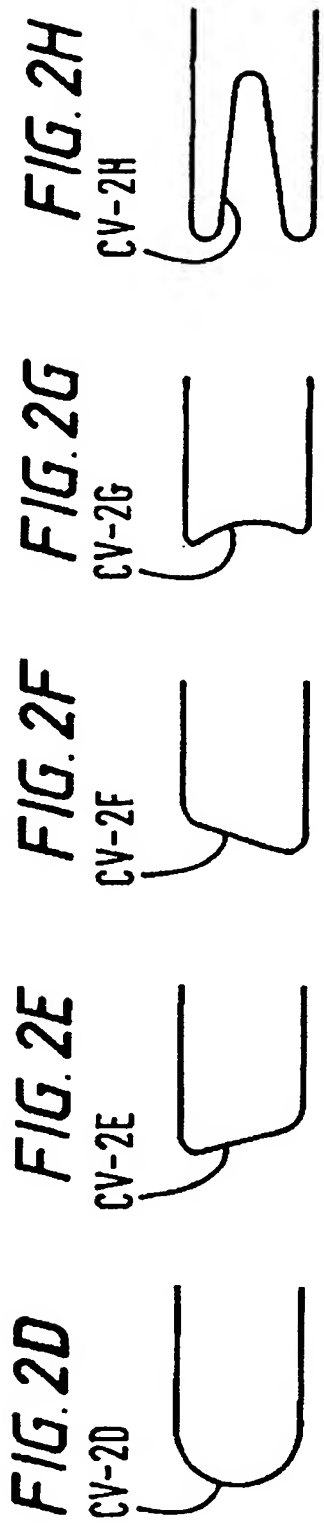


FIG. 2D FIG. 2E FIG. 2F FIG. 2G FIG. 2H

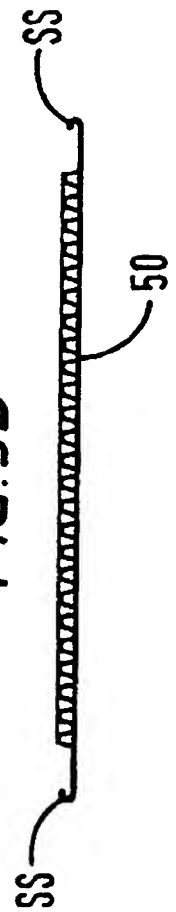
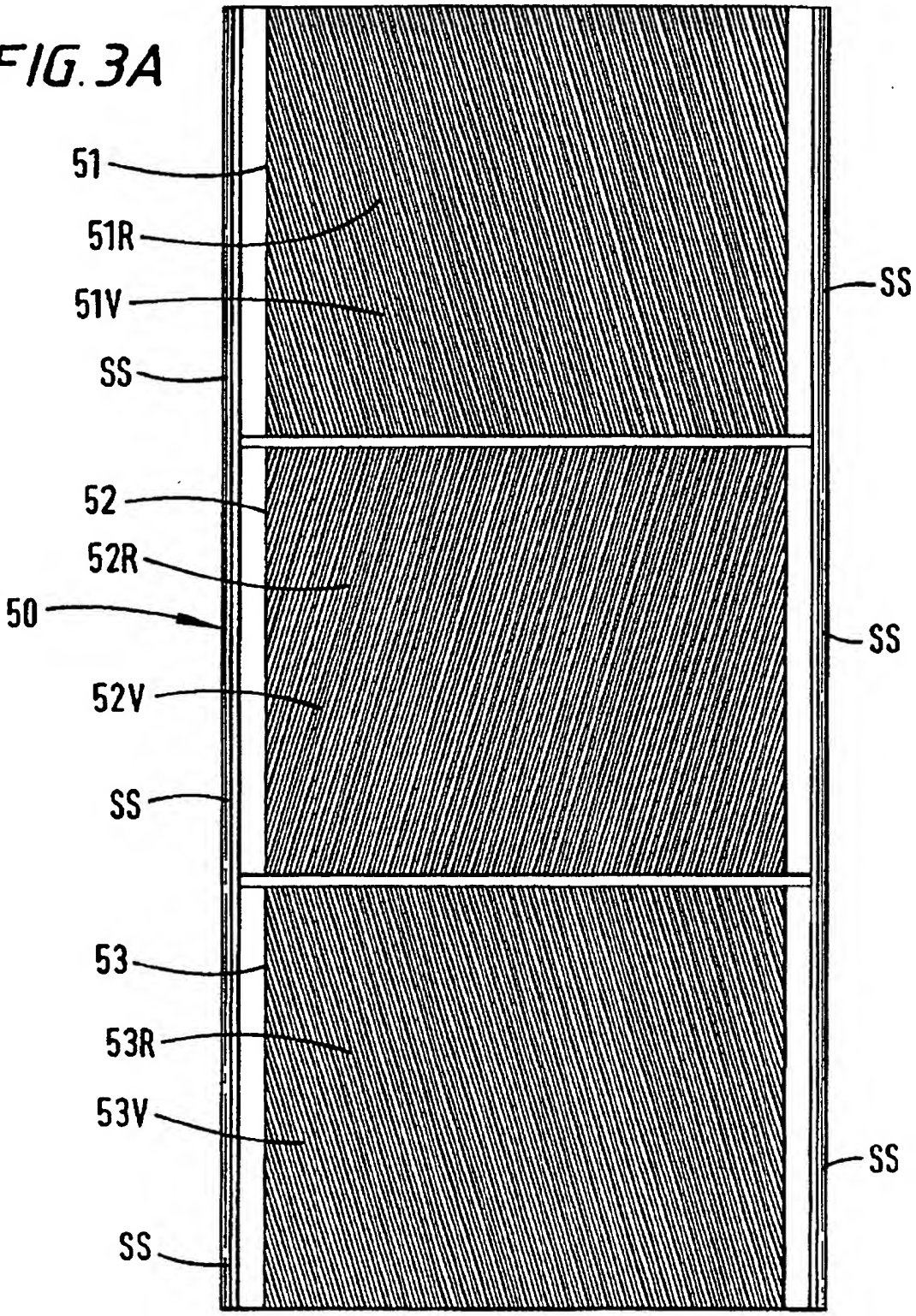


FIG. 3B

FIG. 3A



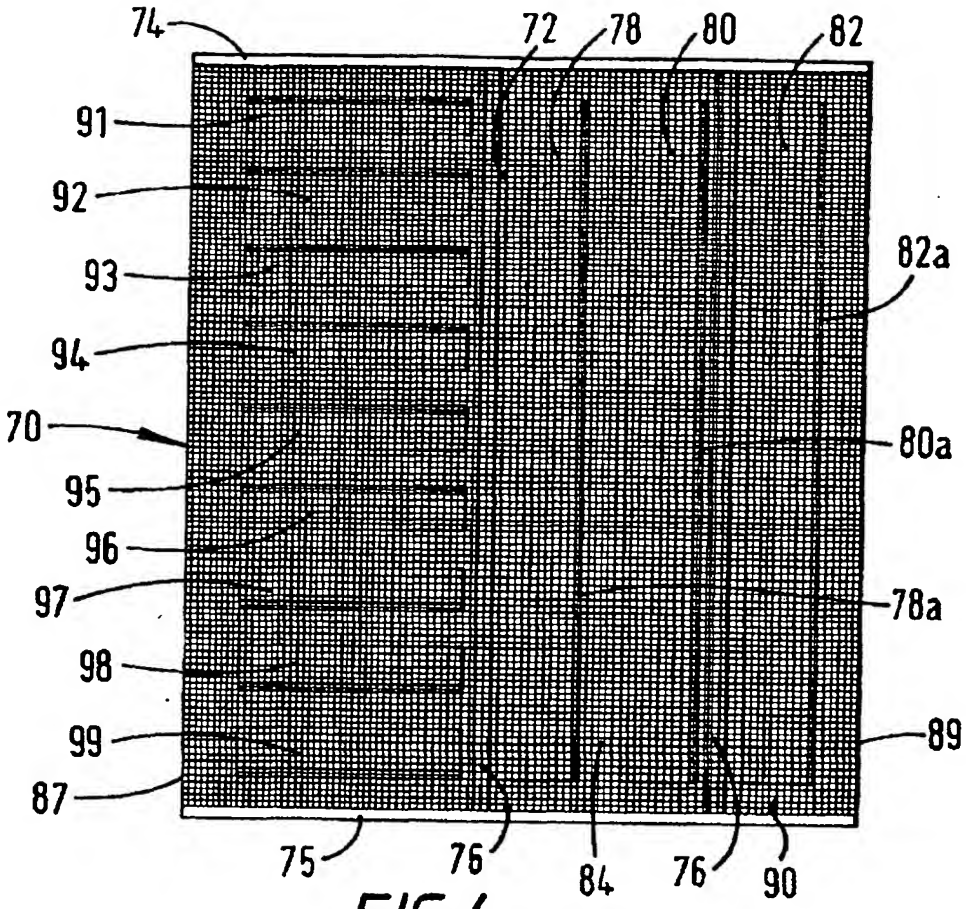


FIG. 4

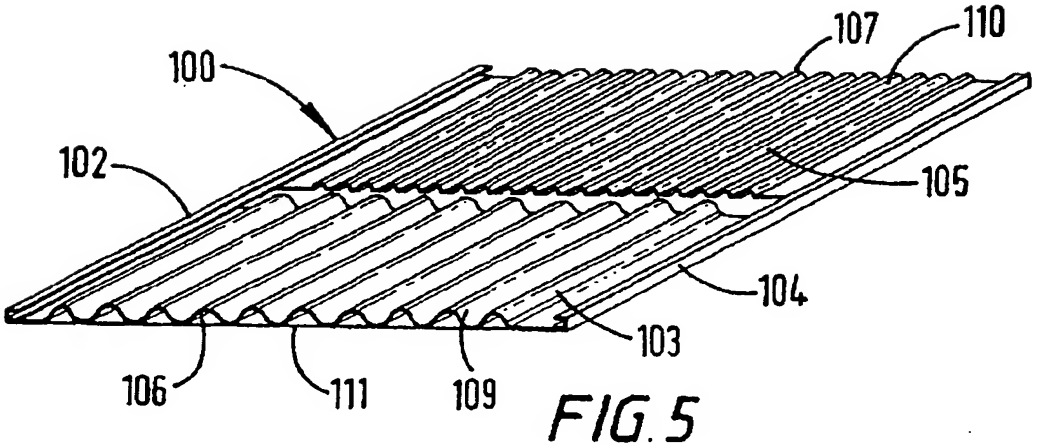


FIG. 5

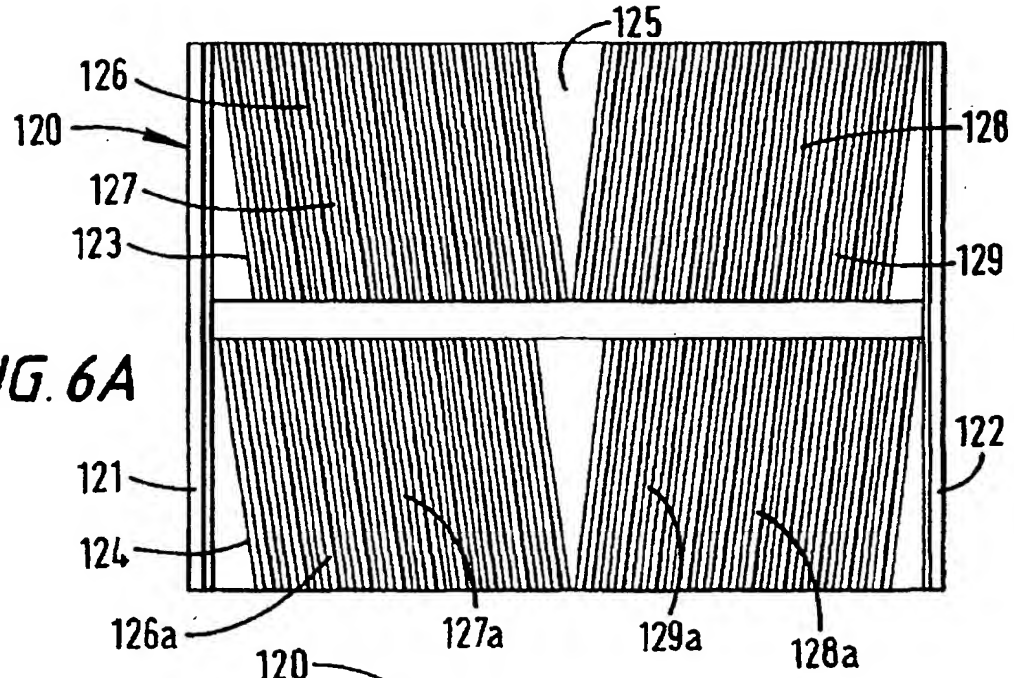


FIG. 6A

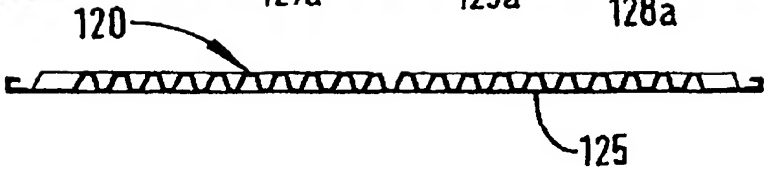


FIG. 6B

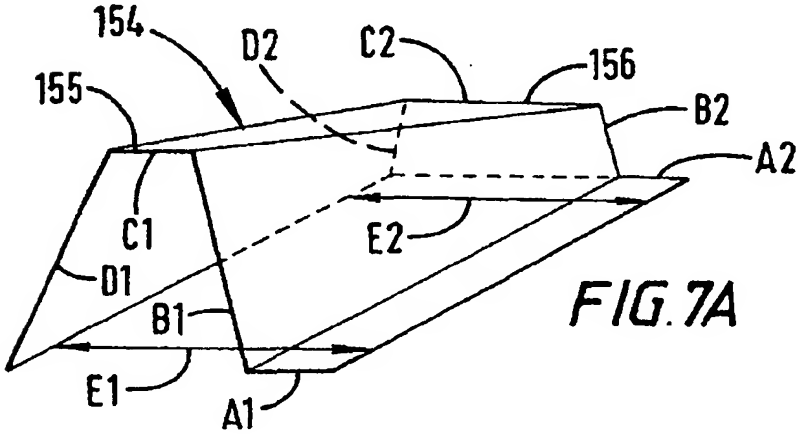


FIG. 7A

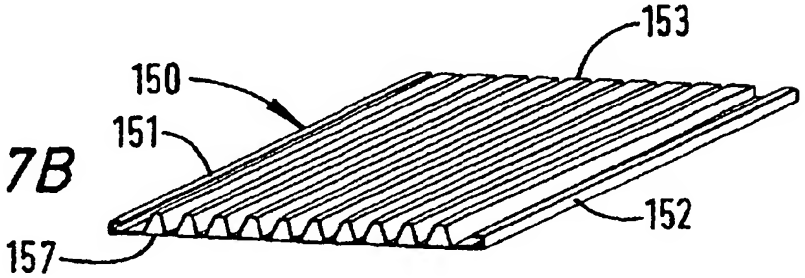


FIG. 7B

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 20 4099

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 868 929 A (DERRICK WILLIAM W ET AL) 9 February 1999 (1999-02-09) * abstract * * column 6, line 17 - line 28 * * claims; figure 10 *	1,2,10, 13,14	B01D33/03 B07B1/46
A	US 5 598 930 A (GRICHAR CHARLES N ET AL) 4 February 1997 (1997-02-04) * the whole document *	1,2,13, 14	
A	WO 97 28906 A (LUCAS BRIAN RONALD ;ADAMS THOMAS COLE (US); LEONE VINCENT DOMINICK) 14 August 1997 (1997-08-14) * the whole document *	1-4,8, 13,14	
A	US 5 551 575 A (LEONE VINCENT D) 3 September 1996 (1996-09-03) * the whole document *	1,11-14	
A	US 1 462 804 A (EDWARD JAMES EVANS) 24 July 1923 (1923-07-24) * the whole document *	10	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
B01D
B07B

The present search report has been drawn up for all claims

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THE HAGUE	4 December 2001	Hilt, D

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The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-12-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5868929 A	09-02-1999	US 5720881 A	24-02-1998
		US 5417858 A	23-05-1995
		US 5944993 A	31-08-1999
		AU 693086 B2	25-06-1998
		AU 6023194 A	15-08-1994
		AU 690096 B2	23-04-1998
		AU 6084494 A	15-08-1994
		AU 714591 B2	06-01-2000
		AU 6593998 A	09-07-1998
		CA 2152602 A1	21-07-1994
		CA 2152610 A1	21-07-1994
		DE 69420701 D1	21-10-1999
		DE 69420701 T2	02-03-2000
		DE 69421381 D1	02-12-1999
		DE 69421381 T2	06-04-2000
		DK 680386 T3	24-01-2000
		DK 680385 T3	31-01-2000
		EP 0680386 A1	08-11-1995
		EP 0680385 A1	08-11-1995
		ES 2137356 T3	16-12-1999
		ES 2135563 T3	01-11-1999
		US 6000556 A	14-12-1999
		WO 9415723 A1	21-07-1994
		WO 9415724 A1	21-07-1994
		US 5417859 A	23-05-1995
		US 5417793 A	23-05-1995
		US 6053332 A	25-04-2000
		US 5783077 A	21-07-1998
		US 5876552 A	02-03-1999
		US 5958236 A	28-09-1999
US 5598930 A	04-02-1997	AT 198558 T	15-01-2001
		AU 6616096 A	18-02-1997
		DE 69611525 D1	15-02-2001
		WO 9703765 A1	06-02-1997
		EP 0843600 A1	27-05-1998
		NO 980119 A	02-03-1998
		US 6267247 B1	31-07-2001
		US 6152307 A	28-11-2000
		US 6032806 A	07-03-2000
		US 6290068 B1	18-09-2001
		US 6269953 B1	07-08-2001
		US 6283302 B1	04-09-2001
		US 6302276 B1	16-10-2001
		US 5971159 A	26-10-1999

EPO FORM P0459

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 20 4099

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The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-12-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9728906 A	14-08-1997	US 5971159 A	26-10-1999
		AT 198168 T	15-01-2001
		AU 1799397 A	28-08-1997
		CA 2240693 A1	14-08-1997
		DE 69703730 D1	25-01-2001
		EP 1002588 A1	24-05-2000
		EP 0880411 A1	02-12-1998
		WO 9728906 A1	14-08-1997
		NO 982680 A	03-08-1998
		US 6029824 A	29-02-2000
		US 6267247 B1	31-07-2001
		US 6152307 A	28-11-2000
		US 6032806 A	07-03-2000
		US 6290068 B1	18-09-2001
		US 6269953 B1	07-08-2001
		US 6283302 B1	04-09-2001
		US 6302276 B1	16-10-2001
		US 5988397 A	23-11-1999
US 5551575 A	03-09-1996	AT 185281 T	15-10-1999
		AU 2924595 A	04-03-1996
		CA 2195207 A1	15-02-1996
		DE 69512668 D1	11-11-1999
		DK 773822 T3	27-12-1999
		WO 9604060 A1	15-02-1996
		EP 0773822 A1	21-05-1997
		NO 965435 A	20-01-1997
US 1462804 A	24-07-1923	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82